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## (54) OSCILLATOR

(71) We, KABUSHIKI KAISHA DAINI SEIKOSHA, a Japanese Company of 31-1, 6-chome, Kameido, Koto-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention concerns an oscillator and, although the invention is not so restricted, it is more particularly concerned with an oscillator which may be employed as a mechanical filter for removing unwanted frequencies, or alternatively may be employed in a portable electric device such, for example, as an electronic watch.

According to the present invention, there is provided an oscillator comprising a piezoelectric or electro-strictive oscillator element which is supported by a first support member for oscillation with respect thereto, the oscillator element being secured to the first support member by way of a layer of adhesive, the oscillator element being provided with at least one electrode having an end portion which extends outwardly of the oscillator element and which is electrically connected to a lead pin, the lead pin forming part of a second support mamber.

The oscillator element is preferably a laminar member.

The said adhesive layer is preferably resilient. Moreover, the said adhesive layer may, if desired, be an electrically conductive layer.

The oscillator element may have an obverse side which is remote from the first support member and which is provided with at least one electrode.

The first support member may be disposed adjacent one end portion of the oscillator element. Moreover, the oscillator element may be provided, adjacent an opposite end portion thereof, with one or more masses.

The oscillator elements may have a reverse surface which is disposed adjacent to the first support member and a part of which is directly secured to the said adhesive layer.

In one particular embodiment of the invention, the oscillator element has a reverse surface which is disposed adjacent to the first support member and is provided with at least one electrode. In this case, the or an electrode on the said reverse surface may be secured to the said adhesive layer.

The oscillator element may if desired be provided with a plurality of tines. Thus each tine may be provided with at least one electrode.

There may for example be three parallel tines the centre one of which in operation oscillates in phase opposition to the outer tines.

The oscillator element is preferably made of quartz, although it can alternatively be made of other piezoelectric materials such as barium titanate, lithium niobate or lead zirconate.

The oscillator element preferably has a thickness not exceeding 100 microns. Thus it may for example have a thickness not exceeding 50 microns.

The invention also comprises a timepiece provided with an oscillator as set forth above.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

Figure 1 illustrates a first embodiment of an oscillator according to the present invention, (A) showing the obverse side of an oscillator element thereof together with its electrodes,

(B) showing the reverse side thereof, and

(C) showing a side view of the oscillator element and electrodes,

Figure 2 is a cross sectional view of an oscillator provided with the oscillator element and electrodes of Figure 1,

Figure 3 is a view similar to Figure 2 but illustrating a modification,

Figure 4 is a top perspective view of a second embodiment of an oscillator according to the present invention,

Figure 5 is a cross-sectional view of the oscillator of Figure 4, and

Figure 6 is a top perspective view of a

third embodiment of an oscillator according to the present invention.

Terms such as "left" and "right" as used in the description below are to be understood to refer to directions as seen in the drawings.

Referring first to the embodiment of Figures 1 and 2, an oscillator according to the present invention comprises a quartz laminar oscillator element 10 which may for example have a length of 5.5mm, a thickness of 25 microns, and a natural frequency of 32 KHz. Alternatively, if desired, the oscillator element 10 may be made of other piezo-electric or electro-strictive materials such as barium titanate, lithium niobate, or lead zirconate.

The oscillator element 10 is shaped as a tuning fork and has two forks or tines 11, 12 each of which may have a length of 2.8 millimetres and a width of 0.315 mm.

The obverse side of the oscillator element 10 is provided with "beam lead" electrodes 13, 14, 15, i.e. with electrodes an end portion of each of which extends outwardly of the oscillator element 10 and is of greater thickness than the main part of the electrode so as to be reinforced with respect to the latter. The electrodes 13, 15 are respectively mounted on the tines 11, 12, the electrode 14 being disposed between the electrodes 13 and 15.

The electrodes 13, 14, 15 have end portions 20, 21, 22 which extend outwardly of the right-hand end portion 23 of the oscillator element 10. Each of the end portions 20, 21, 22 is thicker than the main part of the electrode for reinforcement purposes and is soldered or otherwise bonded to a head 19 of a lead pin 34 (shown in Figure 2) whose other end is conected to an electronic circuit (not shown). Thus each of the electrodes 13, 14, 15 is electrically connected to a respective lead pin. Each lead pin 34 passes through and is carried by a pedestal 29.

The left hand ends of the tines 11, 12 extend beyond the electrodes 13, 14, 15 and are respectively provided on the obverse side of the oscillator element 10, with metal masses 24, 25.

The reverse side of the oscillator element 10 has secured thereto a single electrode 26. However, the left hand ends of the tines 11, 12 extend outwardly of the electrode 26. The electrode 26 has a right hand end portion 30 which extends outwardly beyond the right hand end portion 23 of the oscillator element 10. The end portion 30 is also a so called "beam lead electrode" and is thicker than the remainder of the electrode 26 for reinforcement purposes. The end portion 30 is soldered to a head portion 18 of a lead pin 33 (shown in Figure 2) whose other end portion is connected to an electronic circuit (not shown), the lead pin 33 passing through and being carried by a pedestal or support member 28.

As clearly shown in Figure 2, the oscillator element 10 is secured to an electrically insulating pedestal 31 for oscillation with respect thereto, ~~the pedestal or support mem-~~ber 31 being disposed adjacent to and aligned with the right hand end portion 23 of the oscillator element 10. The electrode 26, ~~which is secured to~~ the surface of the oscillator element 10 which is disposed adjacent to the pedestal 31, is secured to the latter by way of a layer 32 of adhesive, e.g. of raw rubber ~~having resilient properties. The adhesive layer 32 may be either an~~ electrically insulating layer or an electrically conductive layer. The pedestal 31 is secured on a metal case member 27, while the pedestals 28, 29 are mounted in the metal case member 27. The head 18, 19 of these lead pins are respectively connected to the end portions 30, 22 by bonding or soldering. As indicated above, the other end portions 20, 21 are connected to the respective pedestals having lead pins (not shown).

When the oscillator element 10 is mounted on the pedestal 31, and each end portion is bonded to the respective lead pin, the oscillator element is hermetically sealed by a transparent cover 35, which engages the metal case member 27.

Then by applying a lazer beam to the metal masses 24, 25 through transparent cover 35, the oscillating frequency of the oscillator can be adjusted to a predetermined value, because the weight of masses 24, 25 are lessened by evaporation, and this reduction in the weight of the masses 24, 25 increases the said oscillating frequency. Consequently, in order to be able to use the laser beam in this way, the natural frequency of the oscillator must be designed lower than the frequency to which it is to be adjusted.

In the modification shown in Figure 3, the construction is closely similar to that of Figures 1 and 2 except that the end portions 20 to 22 do not extend so far outwardly of the oscillator element 10, while the electrode 26 does not extend longitudinally outwardly of the oscillator element 10 at all. In this case, the oscillator element is mounted on the top of a lead pin 16 by way of a conductive adhesive layer 32 the lead pin 16 passing through and being carried by an insulating pedestal 31. This enables the pedestal 28 to be eliminated.

In the embodiment of the present invention shown in Figures 4 and 5, a quartz or other piezo-electric or electro-strictive lamina oscillator element 36 is supported by an electrically insulating pedestal or support member 37 for oscillation with respect thereto, the oscillator element 36 being secured to the pedestal 37 by way of a layer of adhesive 38. As will be seen from Figure 5,

the oscillator element 36 extends longitudinally outwardly of the pedestal 37 only on the left hand side thereof. As will also be seen from Figure 5, the reverse surface of the oscillator element 36 i.e. the surface adjacent to the pedestal 37 is directly secured to the layer 38 of adhesive. The layer 38 which may be of a raw rubber having resilience, may be either electrically conducting or electrically insulating. The pedestal 37 is secured to a metal case member 27.

In the construction of Figures 4 and 5, the reverse surface of the oscillator element 36 is not provided with an electrode and thus, as explained above, can be directly secured to the layer 38 of adhesive. However, the obverse surface of the oscillator element, i.e. the surface remote from the pedestal 37 is provided with a plurality of electrodes. Thus the oscillator element 36 is formed as a tuning fork having three parallel tines 40, 41, 42, the centre tine 41 of which in operation oscillates in phase opposition to the outer tines 40, 42. The obverse surface of the tine 40 is provided with electrodes 43, 44, the obverse surface of the tine 41 is provided with electrodes 45, 46 and the obverse surface of the tine 42 is provided with electrodes 47, 48.

Each electrode 43 to 48 has a "beam lead" or end portion respectively which extends outwardly of the right-hand end portion of the oscillator element 36. Each beam lead is soldered or bonded to the head 50 of a lead pin 51 respectively, each said head 50 is mounted on a pedestal 49 through which the lead pin 51 passes. The pedestal 49 is made of electrically insulating material and is fixed to the metal case member 27. After encasing the oscillator element 36 by using a transparent cover (not shown), the oscillating frequency is adjusted in a same way as indicated in connection with the embodiment of Figures 1 and 2.

The left hand ends of the obverse surfaces of the tines 40, 41, 42 are respectively provided with masses 56, 57, 58.

The oscillator shown in Figure 6 is generally similar to that of Figures 1 and 2 and therefore will not be described in detail, like reference numerals indicating like parts. In the construction shown in Figure 6, however, the electrodes 13, 14, 15 and the electrode 26 have end portions *20a*, *21a*, *22a* and *30a* respectively which extend outwardly of the oscillator element and sideways of the latter. Each end portion is bent perpendicularly for the benefit of easy electrical connection.

Both the oscillator element 10 and the oscillator element 36 may be produced by a photo-etching technique, using appropriate photolithographic masks (not shown) to achieve the desired dimensions and shape.

Such techniques may include coating an appropriately oriented piezo-electric wafer with a photoresist, exposing the photoresist through a mask defining the shape of the oscillator element, removing the unexposed photoresist and etching away the regions of the piezo-electric wafer not covered by the exposed photoresist.

It has previously proved difficult to effect a satisfactory mounting of a known tuning fork oscillator element which had electrodes disposed on both its observe and reverse surfaces. Moreover, the known oscillator element was liable to be cracked during the process of bonding lead wires thereto because the oscillator element itself is very thin. The oscillator described with reference to the accompanying drawings, however, requires less skill to produce than that of the prior art so that there are fewer rejects. The bonding of the lead pins to the end portions of the electrodes is, moreover, less likely to cause cracking than in the case of the prior art, while the mounting of the oscillator element on a pedestal by way of a layer of resilient adhesive improves the performance of the oscillator under impact. This is an important feature since one of the main applications of the present invention is as an oscillator of an electronic wrist watch. Furthermore, it is easy to mass-produce oscillator elements of this kind, since they are fabricated by a photo-etching technique. In other words, a beam lead is not attached on an electrode as a separate part.

By bonding or soldering a "beam lead" or electrode end portion to a lead pin which is secured on a pedestal, wire bonding is eliminated, because the electrodes are connected electrically to other circuits *via* the pedestal having the lead pin.

WHAT WE CLAIM IS:—

1. An oscillator comprising a piezo-electric or electro-strictive oscillator element which is supported by a first support member for oscillation with respect thereto, the oscillator element being secured to the first support member by way of a layer of adhesive, the oscillator element being provided with at least one electrode having an end portion which extends outwardly of the oscillator element and which is electrically connected to a lead pin, the lead pin forming part of a second support member.

2. An oscillator as claimed in claim 1 in which the oscillator element is a laminar member.

3. An oscillator as claimed in claim 1 or 2 in which the said adhesive layer is resilient.

4. An oscillator as claimed in any preceding claim in which the said adhesive layer is an electrically insulating layer.

5. An oscillator as claimed in any preceding claim in which the oscillator element has an obverse side which is remote from

first support member and which is provided with at least one electrode.

6. An oscillator as claimed in any preceding claim in which the first support member is disposed adjacent one end portion of the oscillator element.

7. An oscillator as claimed in claim 6 in which the oscillator element is provided, adjacent an opposite end portion thereof, with one or more masses.

8. An oscillator as claimed in any preceding claim in which the oscillator element has a reverse surface which is disposed adjacent to the first support member and a part of which is directly secured to the said adhesive layer.

9. An oscillator as claimed in any of claims 1 to 7 in which the oscillator element has a reverse surface which is disposed adjacent to the first support member and is provided with at least one electrode.

10. An oscillator as claimed in claim 9 in which the or an electrode on the said reverse surface is secured to the said adhesive layer.

11. An oscillator as claimed in any preceding claim in which the oscillator element is provided with a plurality of tines.

12. An oscillator as claimed in claim 11 in which each tine is provided with at least one electrode.

13. An oscillator as claimed in claim 11 or 12 in which there are three parallel tines the centre one of which in operation oscillates in phase opposition to the outer tines.

14. An oscillator as claimed in any preceding claim in which the oscillator element is made of quartz, barium titanate, lithium niobate or lead zirconate.

15. An oscillator as claimed in any preceding claim in which the oscillator element has a thickness not exceeding 100 microns.

16. An oscillator substantially as hereinbefore described with reference to and as shown in Figures 1 and 2, or Figure 3, or Figures 4 and 5, or Figure 6 of the accompanying drawings.

17. A timepiece provided with an oscillator as claimed in any preceding claim.

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1465970 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1A.

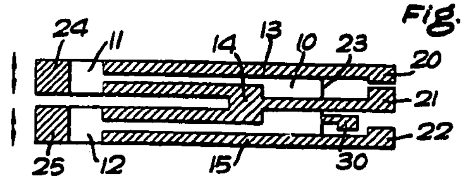
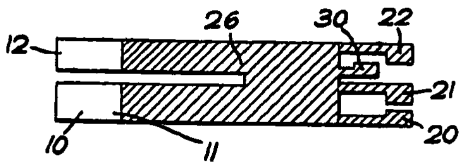



Fig. 1B.



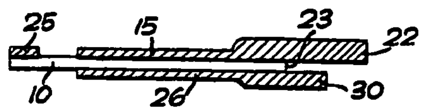




Fig. 1C.

Fig. 2.

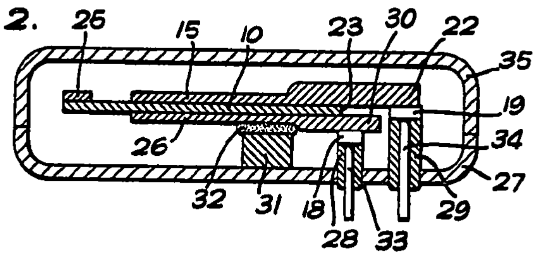



Fig. 3.

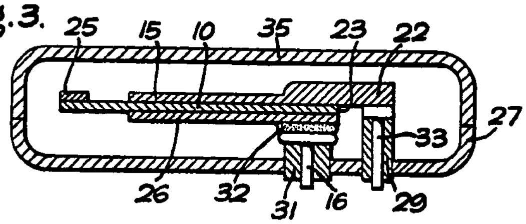


Fig. 4.

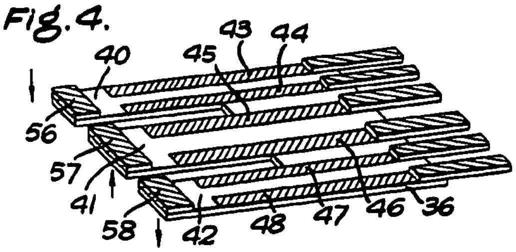



Fig. 5.

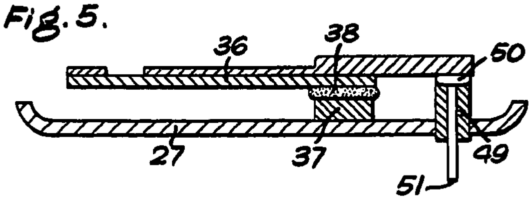



Fig. 6.